BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B70 07035

SUBJECT: Voice Communications On-Board Skylab A. Case 620

DATE: July 2, 1970

FROM: A. G. Weygand

ABSTRACT

The feasibility of using the microphone assembly of one of the two speaker/intercom units (SIU's) mounted in the wardroom of the Orbital Workshop as a pickup of discussions among the crewmembers in the wardroom for real-time transmission to the ground and/or for on-board storage is investigated in this memorandum. A brief description of the voice communications system of the Orbital Assembly (OA) as currently configured is also presented. Because of the necessary restrictions on crew position with respect to a microphone to assure that acceptable rms speech signal to rms noise ratios will be obtained, it is concluded that the microphone assembly of either one of the two SIU's in their current locations in the wardroom could not be reasonably used to pickup conversations occurring in the wardroom.

The most obvious alternative to the use of the microphone assembly of an SIU in this application is to have each of the three crewmen use his own headset which could be connected directly to an audio distribution hardline of the voice communications system of the Orbital Assembly through an umbilical disconnect provided in the hardline which appears at each SIU. Adoption of this alternative will cause no impact to the current design of the voice communications system of the OA.

A second alternative would be to provide a microphone which could be connected to an audio distribution hardline through an umbilical disconnect via a cable sufficiently long to permit the microphone to be properly located to pickup the conversations in the wardroom. It is suggested that a microphone assembly identical to those contained in the SIU's be used as this portable microphone to avoid the added cost of a new design and related hardware qualification.

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MEMORANDUM FOR FILE

At the request of W. Strack, I investigated the feasibility of the suggestion to use the microphone assembly of one of the two speaker/intercom units (SIU's) mounted in the wardroom of the Orbital Workshop (OWS) as a pickup of discussions among the crew members at the end of each work day recapping the day's activities for real-time transmission to the ground and/or for on-board storage.

The voice communications system of the Orbital Assembly (OA) as now configured includes redundant audio distribution hardlines routed in parallel throughout the habitable volume of the Saturn Workshop (SWS). Each of the two audio distribution hardlines includes a separate earphone line pair, a separate microphone line pair, a separate power line pair, various biomedical data lines, various control lines, etc. SIU's will be located for convenient crew access in the work and habitability areas throughout the SWS. Each SIU will contain a microphone assembly, a speaker assembly, and two umbilical disconnects, one in each of the two audio distribution hardlines, which provide each crewman with the capability to connect his headset to either of the two hardlines. The microphone and speaker assemblies in each SIU may be used in conjunction with either one of the redundant hardlines in place of a crewman's headset as determined by a crewman via a switch setting on that SIU thereby providing the crewman with a simplex voice communications capability without using his headset. When the microphone and speaker assemblies of an SIU are being used, the speaker assembly will be connected to the earphone line pair of the selected audio distribution hardline until a crewman operates a push-to-talk (PTT) switch located on that SIU which will connect the microphone assembly to the microphone line pair of that hardline and disconnect the speaker assembly. The audio centers of the Command and Service Module (CSM) will be used under crew control to connect the microphone line pair of each audio distribution hardline with the earphone line pair of that hardline thereby effectively providing two isolated voice communications hardline loops throughout the OA or to connect the microphone and earphone line pairs of both hardlines together thereby effectively providing a single voice communications

hardline loop throughout the OA. The CSM audio center may also be used under crew control to connect either or both voice communications hardline loops to the Unified S-band (USB) system and/or theVHF communication system of the CSM to provide voice communications between the ground and the crew located anywhere in the OA. A control will be provided on each SIU to enable a crewman to control storage of the audio signals present on the earphone line pair of either one of the audio distribution hardlines by at least one of the three tape recorders on-board the SWS. The audio signals stored by a tape recorder on-board the SWS can then be dumped to the ground via a VHF FM transmitter upon command from the ground.

The major question on the use of the microphone assembly of a SIU as a pickup for conversations among the crewman in the wardroom of the SWS (or elsewhere in the OA) is whether the speech sound pressure level reaching the microphone assembly will be sufficiently above the noise sound pressure level reaching the microphone assembly so that the signal-to-noise ratio of the output electrical signal from the microphone assembly will be high enough to ensure good speech intelligibility when the signal is recovered and converted to sound. A requirement included in the Apollo Applications Program Specification states that the OA equipment shall be designed so that a sound pressure level of 55dB in the frequency range from 600 to 4800 Hz will not be exceeded in any manned module of the OA during orbital flight. It should be noted that no acoustic noise measurements have been made in the OWS as yet although some preliminary acoustic noise measurements are scheduled to be made in the near future to determine the level of background noise contributed by the atmospheric circulation fans when operating. In lieu of measured values, it was assumed for the purposes of this brief investigation that the ambient noise pressure level in the wardroom over the frequency band extending from 300 to 3000 Hz (the nominal frequency response of the OA voice communications system) will just meet the specification requirement. It was assumed that the combined sound pressure contributions from all acoustic noise sources reaching the wardroom will be distributed evenly over the frequency range extending from 300 Hz to 4800 Hz and that the noise sound pressure field will be diffuse such that the noise sound pressure waves will approach the microphone assembly of each SIU in the wardroom uniformly and randomly from all possible directions. This translates into an rms noise sound pressure level of approximately 51dB with respect to 0.002 dynes per square centimeter reaching the microphone assembly. From the results of measurements of the average total sound pressure level of normal speech produced

by young male voices in ambient air pressure equivalent to sea level and 35,000 feet made by L. L. Beranek and reported in the September, 1947 issue of the Proceedings of the IRE, it was estimated that the rms speech sound pressure level reaching the microphone assembly in the wardroom will be approximately 63dB with respect to 0.0002 dynes per square centimeter for the case when the talker in a 5.0 psia atmosphere of oxygen and nitrogen is at a distance of one meter from the microphone and when his mouth is directly in front of the microphone. It should be noted that the microphone used in the SIU will have a directional pickup because of its shape and location in the SIU and that the sound pressure waves emanating from a speaker's mouth will also be somewhat directional. Consequently, the intensity of the speech picked up by the microphone will not only depend upon the intensity of the original speech sound and the distance between the mouth of the talker and the microphone but also on the relative orientation of the mouth of the talker and the microphone. Sound pressure in a homogeneous atmosphere will decrease proportionately with the square of the distance from the source.

Although the output versus input characteristics of most microphones are not exactly linear, they are nearly so and for this investigation it was assumed that the microphone assembly will produce an output voltage linearly proportional to the incident sound pressure level. Hence, the rms speech signal to rms noise ratio of the electrical output of the microphone assembly under the conditions and assumptions discussed above will be approximately 12dB. This rms signal to rms noise ratio is close (within 2 to 5dB) to the minimum value generally judged to be acceptable for good word intelligibility. Therefore, in order to use the microphone assembly of the SIU as a pickup for speech, the talker must be closer than 2 meters from the microphone and must be properly positioned in front of the microphone. In my opinion, because of these restrictions, the microphone assembly of either one of the two SIU's in their current locations in the wardroom could not reasonably be used to pickup conversations occurring in the wardroom.

Since there are two SIU's located in the wardroom providing a total of two umbilical disconnects in each of the audio distribution hardlines, the obvious alternative is to connect the two hardlines via the audio centers in the CSM to form a single voice communications loop throughout the OA and to have each of the three crewmen use his own headset which would be connected to one of the four available umbilical disconnects. The headset could be operated in either a "hot mike" or a push-to-talk mode as determined by each crewman. A second

alternative would be to provide a microphone which could be connected to one of the umbilical disconnects via an umbilical cable sufficiently long to permit the microphone to be properly located to pickup the conversations in the wardroom. As indicated by the signal-to-noise ratio discussion above, there would necessarily be restrictions on the relative positions of the crewmen and microphone. If this second alternative were to be pursued, I suggest that a microphone assembly identical to those contained in the SIU's be used because this assembly will have been designed to operate with the audio distribution hardlines of the SWS, designed to operate in a 5.0 psia atmosphere of oxygen and nitrogen, and will have been qualified for use in manned spacecraft although a microphone with an omni-directional pickup capability would be more desirable in this application. The umbilical could be wired so that the output of this microphone assembly would be connected to the microphone line pair of the audio distribution hardline selected and so that the microphone assembly could be powered like a headset. It should be noted, however, that the microphone assembly of the SIU requires + 28 VDC power while + 16.8 VDC power is provided to the headset from the umbilical disconnect on the SIU. A PTT switch should be provided on this portable microphone assembly, although it is likely that such a switch would be secured in the depressed position. If this alternative were to be adopted, then during the periods when the portable microphone was being used, the audio centers of the CSM should be used to provide two isolated voice communications hardline loops throughout the OA, one to be used for recording voice signals and the second to be used for voice communications with the ground. Since there will be two SIU's in the wardroom, the speaker assembly of the second SIU (as well as the first SIU) could be used to receive alarm signals from the SWS caution and warning system to alert the crew and to monitor voice communications from the ground which will appear on one of the two isolated voice communications hardline loops.

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